WHAT IS CLAIMED IS

5

1. An image processing method of quantizing multi-tone image data by an error diffusion method, comprising the steps of:

a) detecting change of the image data; and

10 b) oscillating cyclically in image space a threshold for the quantization in an oscillation range controlled according to the detection result of the step a).

15

2. The image processing method as claimed in claim 1, wherein:

20 the step a) detects an edge degree of the image data by detecting change of the image data; and

the step b) controls the oscillation range of the quantization threshold according to the edge degree in multi-steps.

25

3.   The image processing method as claimed in claim 1, wherein the step a) detects cyclicity of change of the image data by detecting change of the image data.

5

4.   The image processing method as claimed in claim 1, wherein the step a) detects an edge degree of

10   the image data and cyclicity of change of the image data by detecting change of the image data.

15

5.   The image processing method as claimed in claim 1, wherein:

the step a) detects an edge degree of the image data by detecting change of the image data, and

20   performing region expansion processing on the detected edge degree; and

the step b) controls in multi-steps the oscillation range of the quantization threshold according to the edge degree having undergone the region

25   expansion processing.

6. The method as claimed in claim 5, wherein an expansion extent of the region expansion processing is selected to be within 0.5 mm in the image space.

5

7. The method as claimed in claim 1, wherein:

the quantization threshold oscillates

10 approximately around the central value of the data range of the image data;

the maximum oscillation range of the quantization threshold is equal to or larger than 1/3 the data range of the image data; and

15 the image data is quantized into two levels.

20 8. An image processing apparatus comprising:

an error diffusion processing part which quantizes image data by an error diffusion method;

an image data change detecting part which detects change of the image data; and

25 a quantization threshold generating part which

generates a quantization threshold for said error

diffusion processing part, the quantization threshold

oscillating in an oscillation range controlled according

to the detection data output by said image data change

5   detecting part.

10   9.   The apparatus as claimed in claim 8,

wherein:

        said image data change detecting part outputs

detection data indicating an edge degree of the image

data; and

15   said quantization threshold generating part

controls in multi-levels the quantization threshold

according to the detection data output from said image

data change detecting part.

20

        10.   The apparatus as claimed in claim 8,

wherein:

25   said image data change detecting part

comprises a part detecting an edge degree of the image

data, and a part performing region expansion processing

on the edge degree, and outputs detection data

indicating the edge degree having undergone the region

5   expansion processing; and

said quantization threshold generating part

controls the oscillation range of the quantization

threshold according to the detection data output by said

image data change detecting part.

10

11.   The apparatus as claimed in claim 10,

15   wherein an expansion extent of the region expansion

processing is selected to be within 0.5 mm in the image

space.

20

12.   The apparatus as claimed in claim 9,

wherein said quantization threshold generating part

comprises:

25   a first part generating a first fluctuating

value which oscillates in a fixed oscillation range
cyclically in the image space;

       a second part generating a second fluctuating
value obtained from multiplying the first fluctuating
5   value generated by said first part by a multiplication
factor according to the detection data output by said
image data change detecting part; and

       a third part generating the quantization
threshold obtained from adding a fixed value to the
10   second fluctuating value generated by said second part.

15   13.   The apparatus as claimed in claim 10,
wherein said quantization threshold generating part
comprises:

       a first part generating a first fluctuating
value which oscillates in a fixed oscillation range
20   cyclically in the image space;

       a second part generating a second fluctuating
value obtained from multiplying the first fluctuating
value generated by said first part by a multiplication
factor according to the detection data output by said
25   image data change detecting part; and

a third part generating the quantization threshold obtained from adding a fixed value to the second fluctuating value generated by said second part.

5

14.   The apparatus as claimed in claim 9, wherein said quantization threshold generating part

10   comprises:

a first part generating a plurality of fluctuating values which oscillate in respective different oscillation ranges cyclically in the image space; and

15   a second part selecting from the plurality of fluctuating value a fluctuating value having an oscillation range according to the detection data output by said image data change detecting part.

20

15.   The apparatus as claimed in claim 10, wherein said quantization threshold generating part

25   comprises:

a first part generating a plurality of fluctuating values which oscillate in respective different oscillation ranges cyclically in the image space; and

5   a second part selecting from the plurality of fluctuating value a fluctuating value having an oscillation range according to the detection data output by said image data change detecting part.

10

16.   The apparatus as claimed in claim 8, wherein:

15   the quantization threshold oscillates approximately around the central value of the data range of the image data;

the maximum oscillation range of the quantization threshold is equal to or larger than 1/3

20   the data range of the image data; and

the image data is quantized into two levels.

25

17. The apparatus as claimed in claim 8,
further comprising a part forming an image according to
quantized image data obtained as a result of image data
being quantized by said error diffusion part.

5

18. The apparatus as claimed in claim 8,
10 further comprising a part inputting multi-tone image
data by scanning an original image.

15

19. The apparatus as claimed in claim 8,
further comprising:
        a part inputting multi-tone image data by
scanning an original image; and
20   a part forming an image according to quantized
image data obtained as a result of image data being
quantized by said error diffusion part.

25

20. A computer readable recording medium in which a program is recorded, the program being read therefrom and executed by a computer so as to cause said computer to perform the functions of:

5   an error diffusion processing part which quantizes image data by an error diffusion method;

an image data change detecting part which detects change of the image data; and

a quantization threshold generating part which

10   generates a quantization threshold for said error diffusion processing part, the quantization threshold oscillating in an oscillation range controlled according to the detection data output by said image data change detecting part.

15

21. The recording medium as claimed in claim

20   20, wherein:

said image data change detecting part outputs detection data indicating an edge degree of the image data; and

said quantization threshold generating part

25   controls in multi-levels the quantization threshold

according to the detection data output from said image

data change detecting part.

5

22. The apparatus as claimed in claim 20,

wherein:

said image data change detecting part

10 comprises a part detecting an edge degree of the image

data, and a part performing region expansion processing

on the edge degree, and outputs detection data

indicating the edge degree having undergone the region

expansion processing; and

15 said quantization threshold generating part

controls the oscillation range of the quantization

threshold according to the detection data output by said

image data change detecting part.

20

23. The recording medium as claimed in claim

21, wherein said quantization threshold generating part

25 comprises:

a first part generating a first fluctuating value which oscillates in a fixed oscillation range cyclically in the image space;

a second part generating a second fluctuating
5 value obtained from multiplying the first fluctuating value generated by said first part by a multiplication factor according to the detection data output by said image data change detecting part; and

a third part generating the quantization
10 threshold obtained from adding a fixed value to the second fluctuating value generated by said second part.

15

24. The recording medium as claimed in claim 22, wherein said quantization threshold generating part comprises:

a first part generating a first fluctuating
20 value which oscillates in a fixed oscillation range cyclically in the image space;

a second part generating a second fluctuating value obtained from multiplying the first fluctuating value generated by said first part by a multiplication
25 factor according to the detection data output by said

image data change detecting part; and

a third part generating the quantization threshold obtained from adding a fixed value to the second fluctuating value generated by said second part.

5

25. The recording medium as claimed in claim

10 21, wherein said quantization threshold generating part comprises:

a first part generating a plurality of fluctuating values which oscillate in respective different oscillation ranges cyclically in the image

15 space; and

a second part selecting from the plurality of fluctuating value a fluctuating value having an oscillation range according to the detection data output by said image data change detecting part.

20

26. The recording medium as claimed in claim

25 22, wherein said quantization threshold generating part

comprises:

a first part generating a plurality of
fluctuating values which oscillate in respective
different oscillation ranges cyclically in the image
5 space; and

a second part selecting from the plurality of
fluctuating value a fluctuating value having an
oscillation range according to the detection data output
by said image data change detecting part.

10

27.   An image processing apparatus comprising:
15   an error diffusion processing part which
quantizes multi-tone image data by an error diffusion
method; and

a quantization threshold generating part which
generates a quantization threshold for said error
20 diffusion processing part, the quantization threshold
oscillating cyclically,

wherein said quantization threshold generating
part generates the quantization threshold using a dither
threshold matrix for forming halftone spots at an image
25 space frequency in a range of 100 cycles per inch

through 250 cycles per inch.

5

        28. An image processing apparatus comprising:

        an error diffusion processing part which quantizes multi-tone image data by an error diffusion method; and

10   a quantization threshold generating part which generates a quantization threshold for said error diffusion processing part, the quantization threshold oscillating cyclically,

        wherein said quantization threshold generating 15 part generates the quantization threshold using a dot-concentration dither-threshold matrix having a screen angle of around 45°.

20

        29. An image processing apparatus comprising:

        an error diffusion processing part which quantizes image data by an error diffusion method; and

25   a quantization threshold generating part which

generates a quantization threshold for said error

diffusion processing part, the quantization threshold

oscillating cyclically,

wherein said quantization threshold generating

5   part generates the quantization threshold using a dot-

concentration dither-threshold matrix obtained from

combining a plurality of basic dither threshold matrixes,

wherein adjacent basic dither threshold matrixes are

relatively shifted by a half phase in a direction

10   perpendicular to the adjacent direction.

15   30.   The apparatus as claimed in claim 29,

wherein each basic dither threshold matrix has a size of

four pixels in a main scanning direction and four pixels

in a sub-scanning direction.

20

31.   The apparatus as claimed in claim 29,

wherein each dither threshold matrix is such that a

25   cycle of halftone-spot development starting point is

eight pixels in a main scanning direction and four

pixels in a sub-scanning direction.

5

32. An image processing apparatus comprising:

an error diffusion processing part which

quantizes multi-tone image data by an error diffusion

10   method; and

a quantization threshold generating part which

generates a quantization threshold for said error

diffusion processing part, the quantization threshold

oscillating cyclically,

15   wherein said quantization threshold generating

part generates the quantization threshold using a dot-

concentration dither-threshold matrix for forming lines

extending in a sub-scanning direction.

20

33. The apparatus as claimed in claim 27,

further comprising an edge detecting part detecting an

25   edge level of the image data input to said error

diffusion processing part,

wherein an oscillation range of the quantization threshold is controlled according to the edged level detected by said edge detecting part.

5

34.   The apparatus as claimed in claim 28,
10   further comprising an edge detecting part detecting an edge level of the image data input to said error diffusion processing part,

wherein an oscillation range of the quantization threshold is controlled according to the
15   edged level detected by said edge detecting part.

20   35.   The apparatus as claimed in claim 29, further comprising an edge detecting part detecting an edge level of the image data input to said error diffusion processing part,

wherein an oscillation range of the
25   quantization threshold is controlled according to the

edged level detected by said edge detecting part.

5

36. The apparatus as claimed in claim 32,
further comprising an edge detecting part detecting an
edge level of the image data input to said error
diffusion processing part,

10   wherein an oscillation range of the
quantization threshold is controlled according to the
edged level detected by said edge detecting part.

15

37. The apparatus as claimed in claim 27,
further comprising an edge detecting part detecting an
edge level of the image data input to said error

20 diffusion processing part and a region expansion
processing part performing region expansion processing
on the edge level detected by said edge detecting part,
       wherein an oscillation range of the
quantization threshold is controlled according to the

25 edged level having undergone the region expansion

processing performed by said region expansion processing part.

5

38. The apparatus as claimed in claim 28, further comprising an edge detecting part detecting an edge level of the image data input to said error

10   diffusion processing part and a region expansion processing part performing region expansion processing on the edge level detected by said edge detecting part, wherein an oscillation range of the quantization threshold is controlled according to the

15   edged level having undergone the region expansion processing performed by said region expansion processing part.

20

39. The apparatus as claimed in claim 29, further comprising an edge detecting part detecting an edge level of the image data input to said error

25   diffusion processing part and a region expansion

processing part performing region expansion processing

on the edge level detected by said edge detecting part,

       wherein an oscillation range of the

quantization threshold is controlled according to the

5   edged level having undergone the region expansion

processing performed by said region expansion processing

part.

10

       40.   The apparatus as claimed in claim 32,

further comprising an edge detecting part detecting an

edge level of the image data input to said error

15   diffusion processing part and a region expansion

processing part performing region expansion processing

on the edge level detected by said edge detecting part,

       wherein an oscillation range of the

quantization threshold is controlled according to the

20   edged level having undergone the region expansion

processing performed by said region expansion processing

part.

25

41. An image processing apparatus comprising:

an error diffusion processing part which
quantizes multi-tone image data by an error diffusion
method;

5   a quantization threshold generating part which
uses a dither threshold matrix and generates a
quantization threshold for said error diffusion
processing part, the quantization threshold oscillating
cyclically; and

10   an edge detecting part detecting an edge level
of the image data input to said error diffusion
processing part,

wherein said error diffusion processing part
controls an oscillation range of the quantization
15   threshold according to the edged level detected by said
edge detecting part, and, also, switches the dither
threshold matrix used for generation of the quantization
threshold according to a mode specified externally.

20

42. An image processing apparatus comprising:

an error diffusion processing part which
25   quantizes multi-tone image data by an error diffusion

method;

a quantization threshold generating part which
uses a dither threshold matrix and generates a
quantization threshold for said error diffusion
5   processing part, the quantization threshold oscillating
cyclically;

an edge detecting part detecting an edge level
of the image data input to said error diffusion
processing part; and

10   a region expansion processing part performing
region expansion processing on the edge level detected
by said edge detecting part,

wherein said error diffusion processing part
controls an oscillation range of the quantization
15   threshold according to the edged level having undergone
the region expansion processing performed by said region
expansion processing part, and, also, switches the
dither threshold matrix used for generation of the
quantization threshold according to a mode specified
20   externally.

25   43. A computer readable recording medium in

which a program is recorded, the program being read

therefrom and executed by a computer so as to cause said

computer to perform the functions of:

an error diffusion processing part which

5   quantizes multi-tone image data by an error diffusion

method; and

a quantization threshold generating part which

generates a quantization threshold for said error

diffusion processing part, the quantization threshold

10   oscillating cyclically,

wherein said quantization threshold generating

part generates the quantization threshold using a dither

threshold matrix for forming halftone spots at an image

space frequency in a range of 100 cycles per inch

15   through 250 cycles per inch.

20   44.   A computer readable recording medium in

which a program is recorded, the program being read

therefrom and executed by a computer so as to cause said

computer to perform the functions of:

an error diffusion processing part which

25   quantizes multi-tone image data by an error diffusion

method; and

a quantization threshold generating part which generates a quantization threshold for said error diffusion processing part, the quantization threshold

5   oscillating cyclically,

wherein said quantization threshold generating part generate the quantization threshold using a dot-concentration dither-threshold matrix having a screen angle of around 45°.

10

45.   A computer readable recording medium in

15   which a program is recorded, the program being read therefrom and executed by a computer so as to cause said computer to perform the functions of:

an error diffusion processing part which quantizes multi-tone image data by an error diffusion

20   method; and

a quantization threshold generating part which generates a quantization threshold for said error diffusion processing part, the quantization threshold oscillating cyclically,

25   wherein said quantization threshold generating

part generates the quantization threshold using a dot

concentration dither threshold matrix obtained from

combining a plurality of basic dither threshold matrixes,

wherein adjacent basic dither threshold matrixes are

5   relatively shifted by a half phase in a direction

perpendicular to the adjacent direction.

10

        46.   A computer readable recording medium in

which a program is recorded, the program being read

therefrom and executed by a computer so as to cause said

computer to perform the functions of:

15   an error diffusion processing part which

quantizes multi-tone image data by an error diffusion

method; and

        a quantization threshold generating part which

generates a quantization threshold for said error

20   diffusion processing part, the quantization threshold

oscillating cyclically,

        wherein said quantization threshold generating

part generates the quantization threshold using a dot-

concentration dither-threshold matrix for forming lines

25   extending in a sub-scanning direction.

47. A computer readable recording medium in which a program is recorded, the program being read therefrom and executed by a computer so as to cause said computer to perform the functions of:

5   an error diffusion processing part which quantizes multi-tone image data by an error diffusion method;

a quantization threshold generating part which uses a dither threshold matrix and generates a

10   quantization threshold for said error diffusion processing part, the quantization threshold oscillating cyclically; and

an edge detecting part detecting an edge level of the image data input to said error diffusion

15   processing part,

wherein said error diffusion processing part controls an oscillation range of the quantization threshold according to the edged level detected by said edge detecting part, and, also, switches the dither

20   threshold matrix used for generation of the quantization threshold according to a mode specified externally.

25

48. A computer readable recording medium in
which a program is recorded, the program being read
therefrom and executed by a computer so as to cause said
computer to perform the functions of:

5   an error diffusion processing part which
quantizes multi-tone image data by an error diffusion
method;

        a quantization threshold generating part which
uses a dither threshold matrix and generates a
10 quantization threshold for said error diffusion
processing part, the quantization threshold oscillating
cyclically;

        an edge detecting part detecting an edge level
of the image data input to said error diffusion
15 processing part; and

        a region expansion processing part performing
region expansion processing on the edge level detected
by said edge detecting part,

        wherein said error diffusion processing part
20 controls an oscillation range of the quantization
threshold according to the edged level having undergone
the region expansion processing performed by said region
expansion processing part, and, also, switches the
dither threshold matrix used for generation of the
25 quantization threshold according to a mode specified

externally.

5

49. An image forming method comprising the
steps of:

a) quantizing multi-tone image data through
quantization processing by an error diffusion method;

10   b) forming an image by outputting dots
according to quantized data obtained from the step a);
and

c) oscillating a quantization threshold for
the quantization processing so as to develop output dots

15 spirally outward in a specific cycle in an image space
as a shade level of the multi-tone image data increases.

20

50. The method as claimed in claim 49,
wherein:

said step a) performs the quantization
processing in the image space from the top left to the

25 bottom right; and

said step c) controls oscillation of the quantization threshold so as to develop the output dots clockwise.

5

51. The method as claimed in claim 49, wherein:

10   said step a) performs the quantization processing in the image space from the top right to the bottom left; and

said step c) controls oscillation of the quantization threshold so as to develop the output dots

15 counterclockwise.

20   52. The method as claimed in claim 49, wherein:

said step c) controls oscillation of the quantization threshold so as to develop the output dots dispersedly for a high shade level region of the multi-

25 tone image data.

53. An image forming method comprising the steps of:

a) quantizing multi-tone image data through quantization processing by an error diffusion method;

5   b) forming an image by outputting dots according to quantized data obtained from the step a); and

c) oscillating a quantization threshold for the quantization processing so as to develop output dots

10   concentratedly in a central portion of a specific cycle in an image space for a low shade level region of the multi-tone image data and develop output dots so as to disperse radially in a peripheral portion of the cycle for a middle or high shade level region of the multi-

15   tone image data.

20   54. The method as claimed in claim 49, wherein said step c) controls oscillation of the quantization threshold so as to develop the output dots in a sub-scanning direction with priority for a low shade level region of the multi-tone image data.

25

55. The method as claimed in claim 53,

wherein said step c) controls oscillation of the

quantization threshold so as to develop the output dots

in a sub-scanning direction with priority for a low

5   shade level region of the multi-tone image data.

10   56. An image processing apparatus comprising:

a quantization threshold generating part

generating a cyclically oscillating quantization

threshold; and

an error diffusion processing part quantizing

15 input multi-tone image data using the quantization

threshold generated by said quantization threshold

generating part by an error diffusion method, and

outputting quantized data,

wherein said quantization threshold generating

20 part generates the quantization threshold using a dither

threshold matrix in which thresholds are arranged

spirally outward in the ascending order.

25

57. The apparatus as claimed in claim 56,
wherein said dither threshold matrix is such that the
threshold sequentially increases clockwise.

5

58. The apparatus as claimed in claim 56,
wherein said dither threshold matrix is such that the

10   threshold sequentially increases counterclockwise.

15   59. The apparatus as claimed in claim 56,
wherein said dither threshold matrix is such that the
thresholds are arranged dispersedly in the ascending
order in the peripheral portion thereof

20

60. An image processing apparatus comprising:
a quantization threshold generating part

25 generating a cyclically oscillating quantization

threshold; and

an error diffusion processing part quantizing
input multi-tone image data using the quantization
threshold generated by said quantization threshold

5   generating part by an error diffusion method, and
outputting quantized data,

wherein said quantization threshold generating
part generates the quantization threshold using a dither
threshold matrix in which small thresholds are arranged

10   concentratedly in the central portion and thresholds
larger than them are dispersedly arranged radially in
the ascending order in the peripheral portion.

15

61.   The apparatus as claimed in claim 56,
wherein in the central portion of the dither threshold
matrix, the thresholds are arranged in the ascending

20   order so as to be arranged in a sub-scanning direction
with priority

25

62. The apparatus as claimed in claim 60, wherein in the central portion of the dither threshold matrix, the thresholds are arranged in the ascending order so as to be arranged in a sub-scanning direction

5   with priority

10   63. The apparatus as claimed in claim 56, further comprising an edge detecting part detecting an edge level of the multi-tone image data,

wherein said quantization threshold generating part controls an oscillation range of the quantization

15 threshold according to the edge level detected by said edge detecting part.

20

64. The apparatus as claimed in claim 60, further comprising an edge detecting part detecting an edge level of the multi-tone image data,

wherein said quantization threshold generating

25 part controls an oscillation range of the quantization

threshold according to the edge level detected by said
edge detecting part.

5

65. The apparatus as claimed in claim 56,
further comprising an edge detecting part detecting an
edge level of the multi-tone image data; and a region
10 expansion processing part performing region expansion
processing on the edge level detected by said edge
detecting part,

wherein said quantization threshold generating
part controls an oscillation range of the quantization
15 threshold according to the edge level having undergone
the region expansion processing performed by said region
expansion processing part.

20

66. The apparatus as claimed in claim 60,
further comprising an edge detecting part detecting an
edge level of the multi-tone image data; and a region
25 expansion processing part performing region expansion

processing on the edge level detected by said edge
detecting part,

wherein said quantization threshold generating
part controls an oscillation range of the quantization
5   threshold according to the edge level having undergone
the region expansion processing performed by said region
expansion processing part.

10

67.   A computer readable recording medium in
which a program is recorded, the program being read
therefrom and executed by a computer so as to cause said
15   computer to perform the functions of:
a quantization threshold generating part
generating a cyclically oscillating quantization
threshold; and
an error diffusion processing part quantizing
20   input multi-tone image data using the quantization
threshold generated by said quantization threshold
generating part by an error diffusion method, and
outputting quantized data,
wherein said quantization threshold generating
25   part generates the quantization threshold using a dither

threshold matrix in which thresholds are arranged
spirally outward in the ascending order.

5

68.   The recording medium as claimed in claim
67, wherein said dither threshold matrix is such that
the threshold sequentially increases clockwise.

10

69.   The recording medium as claimed in claim
15   67, wherein said dither threshold matrix is such that
the threshold sequentially increases counterclockwise.

20

70.   The recording medium as claimed in claim
67, wherein said dither threshold matrix is such that
the thresholds are arranged dispersedly in the ascending
order in the peripheral portion thereof.

25

71. A computer readable recording medium in which a program is recorded, the program being read therefrom and executed by a computer so as to cause said computer to perform the functions of:

5   a quantization threshold generating part generating a cyclically oscillating quantization threshold; and

an error diffusion processing part quantizing input multi-tone image data using the quantization

10   threshold generated by said quantization threshold generating part by an error diffusion method, and outputting quantized data,

wherein said quantization threshold generating part generates the quantization threshold using a dither

15   threshold matrix in which small thresholds are arranged concentratedly in the central portion and thresholds larger than them are dispersedly arranged radially in the ascending order in the peripheral portion.

20

72. The recording medium as claimed in claim 67, wherein in the central portion of the dither

25   threshold matrix, the thresholds are arranged in the

ascending order so as to be arranged in a sub-scanning direction with priority.

5

73.   The recording medium as claimed in claim 71, wherein in the central portion of the dither threshold matrix, the thresholds are arranged in the

10   ascending order so as to be arranged in a sub-scanning direction with priority.